Precipitation

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Learning Outcome

- At the end of this section students will be able to
  - Explain different forms of precipitation
  - Identify different types of rain gauges
  - Measure rainfall using rain guages
  - Calculate mean annual rainfall
  - Calculate rainfall intensity from a rainfall chart
  - Calculate average depth of rainfall over an area
  - Estimate missing rainfall data

- Pure air - condensation of water vapor to liquid water droplets when air become greatly supersaturated
- Presence of small airborne particles called aerosols
  - provides nuclei around which water vapor in normal saturated air can condense
- Two main types of condensation nuclei
  - hygroscopic particles (salt) - make condensation before air becomes saturated
  - non-hygroscopic particles (dust, smoke & ash) needs some degree of supersaturation depending on their size
  - Hygroscopic = tending to absorb moisture from the air

- Other conditions that must be fulfilled before precipitation occur
  - moist air must be cooled to near its dew point. It can be brought about by several way;
    - by an adiabatic (heat does not enter or leave the system concerned) expansion of rising air
      - net heat transfer to or from is zero
      - Increase in volume without heat flow, in or out
    - by meeting two very different air masses
    - by contact between a moist air mass and a cooled object such as the ground.
  - **Dew Point**
    - temperature at which a mass of unsaturated air becomes saturated when cooled with the pressure remaining constant
    - Cooling of air beyond this point would result in condensation or mist formation.

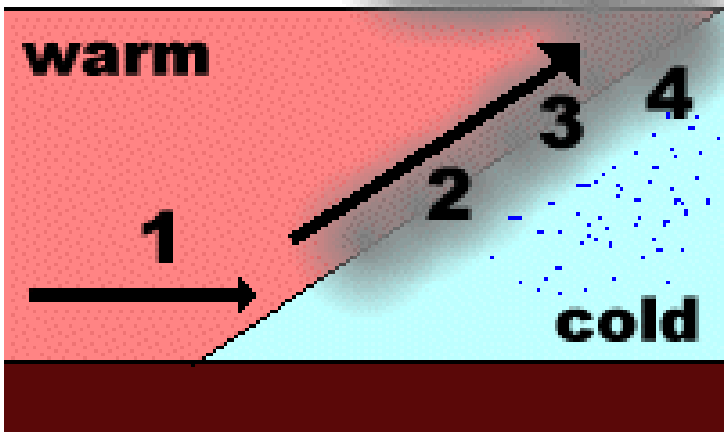
Types of Precipitation

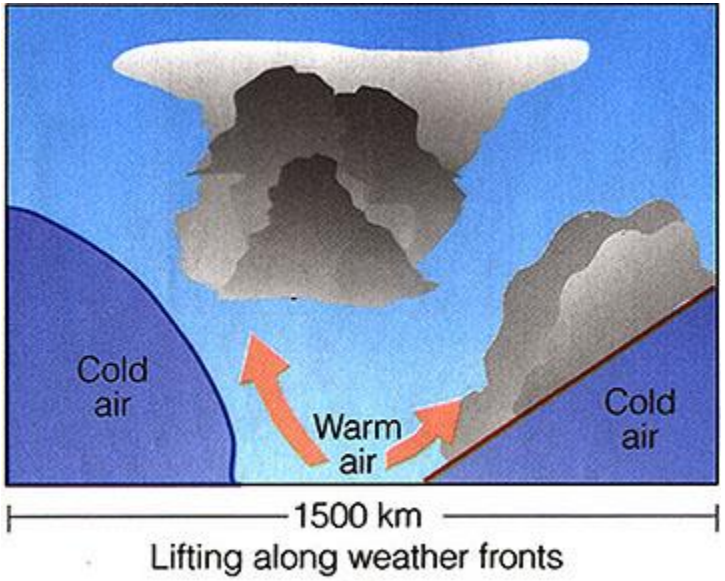
- Convective precipitation
  - due to fall in temperature of an air mass may be by convection
  - warm moist air rise and cool to form cloud
  - these rains generally concentrated and intense (up to 100 mm in two hours)
  - distribution of rainfall is much more local and irregular

- Orographic precipitation
  - resulted from ocean air streams passing over land and being deflected upward by coastal mountains
  - cooling below saturation temperature
- Cyclonic precipitation
  - occur when low pressure areas exists
  - air tends to move into such areas from surrounding
  - Displace low pressure air upward to cool and precipitation

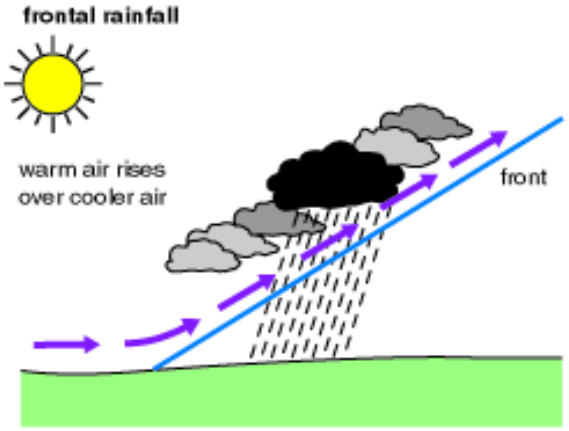
- Frontal precipitation
  - When two air masses of different origin meet (one warm and the other cold)
  - This causes a front.
  - When mass of warm air meets mass of cold air, the, lighter warm air rises above the denser and heavier cold air mass.
  - When the warm air is pushed upwards it cools.
  - When air goes above the point of dew formation and is no longer able to hold all its water within, it begins to condense and form clouds.
  - This leads to precipitation. This rain falls over a wide area.

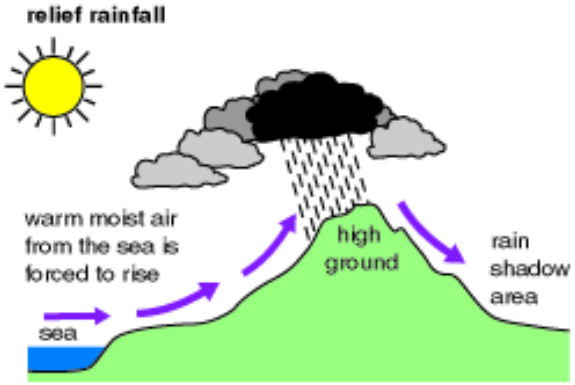
frontal rainfall

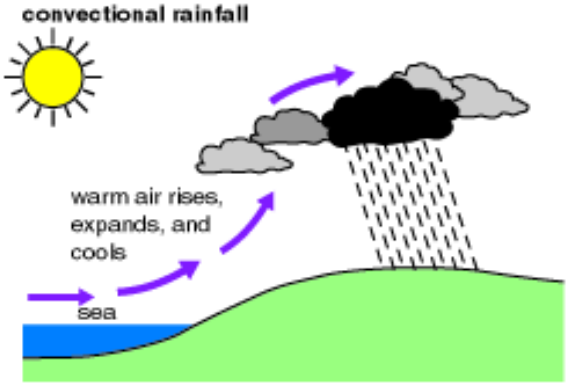




Lifting along weather fronts







Monsoons

- Weather patterns of seasonal winds
- Caused by widespread changes in atmospheric pressure
- Monsoonal precipitation governed by changing seasonal winds
- Monsoon and other seasons in Sri Lanka

Rainfall season	Period	Average Rainfall (mm)	% of Annual Total
1st Inter-monsoon	March – April	268	14
South-West Monsoon	May – Sep	556	30
2nd Inter-monsoon	Oct – Nov	558	30
North-East Monsoon	Dec – Feb	479	26
Total		1861	

Forms of precipitation

Liquid Precipitation

- Rain – water droplets bigger than 0.5 mm in diameter
  - Light rain – upto 2.5 mm/h
  - Moderate rain – 2.5 to 7.5 mm/h
  - Heavy rain – more than 7.5 mm/h
- Drizzle – water droplets less than 0.5 mm in diameter and intensity < 1 mm/h

Solid state precipitation

- Snow – ice crystals resulting from direct conversion of water vapor to ice
- Sleet – rain drops cooled to ice when falling through air at subfreezing temperature
- Hail – small lumps of ice formed by alternate freezing and melting when they are carried up and down by air currents
- Dew – direct condensation and absorption from atmosphere

Rainfall

- The amount of rainfall is expressed as depth in cm (or mm) which falls on level surface
- Rainfall measured by means of rain gauges which classified as

  (i) non – recoding type rain gauges

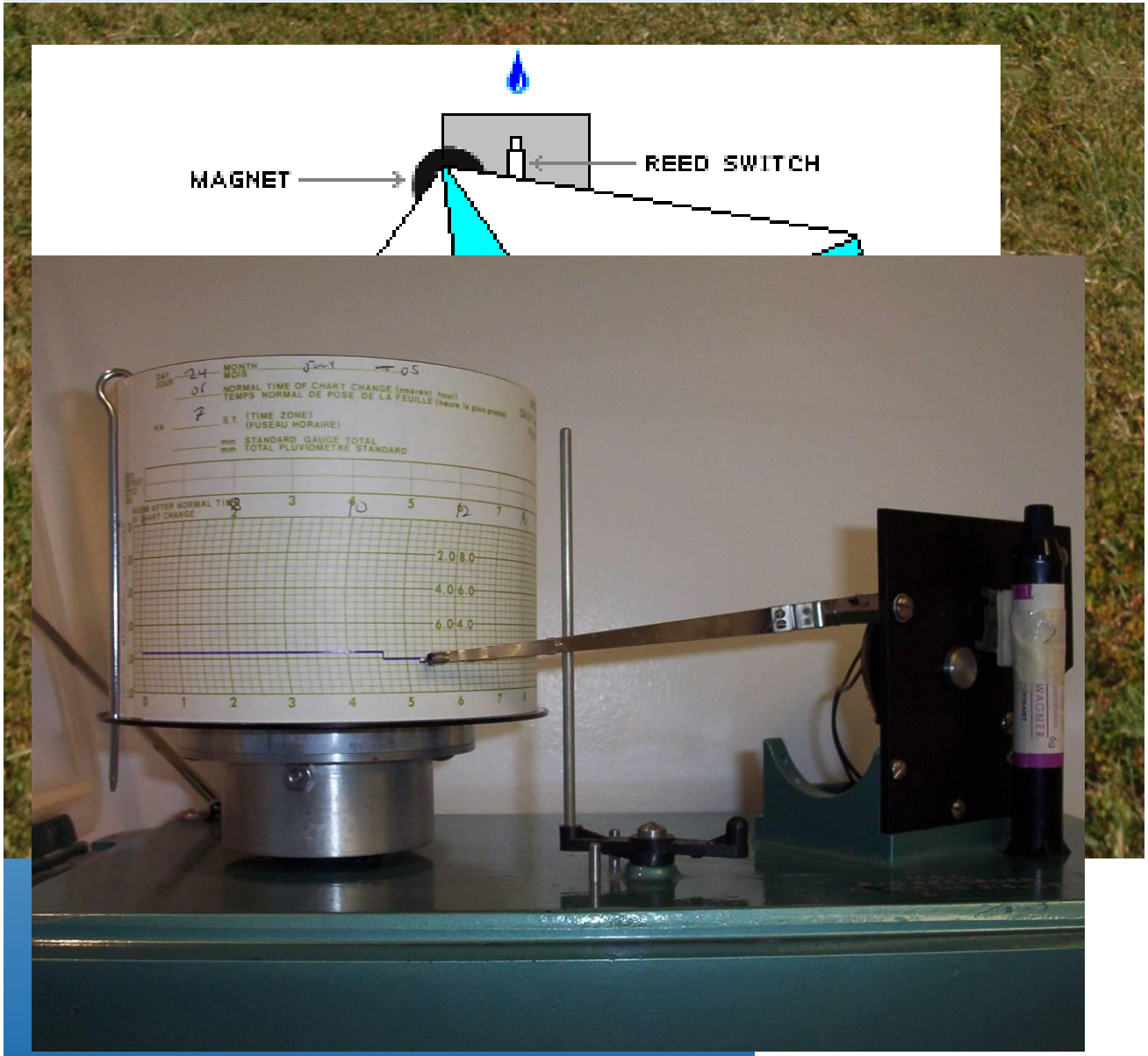
  (ii) recording type rain gauges
- Rain gauges - show

Recording type rain gauge

- Amount of rainfalls with respect to time is recorded in a graph paper – show graph paper(s) in class
- It is possible to calculate the intensity of rainfall for any time interval.
- Three types of recording rain gauges are used.
  - Float
  - Weighing
  - Tipping bucket

Recording Rain gauges

Float type



bucket

0.25 mm rainfall

Non–recording type rain gauge

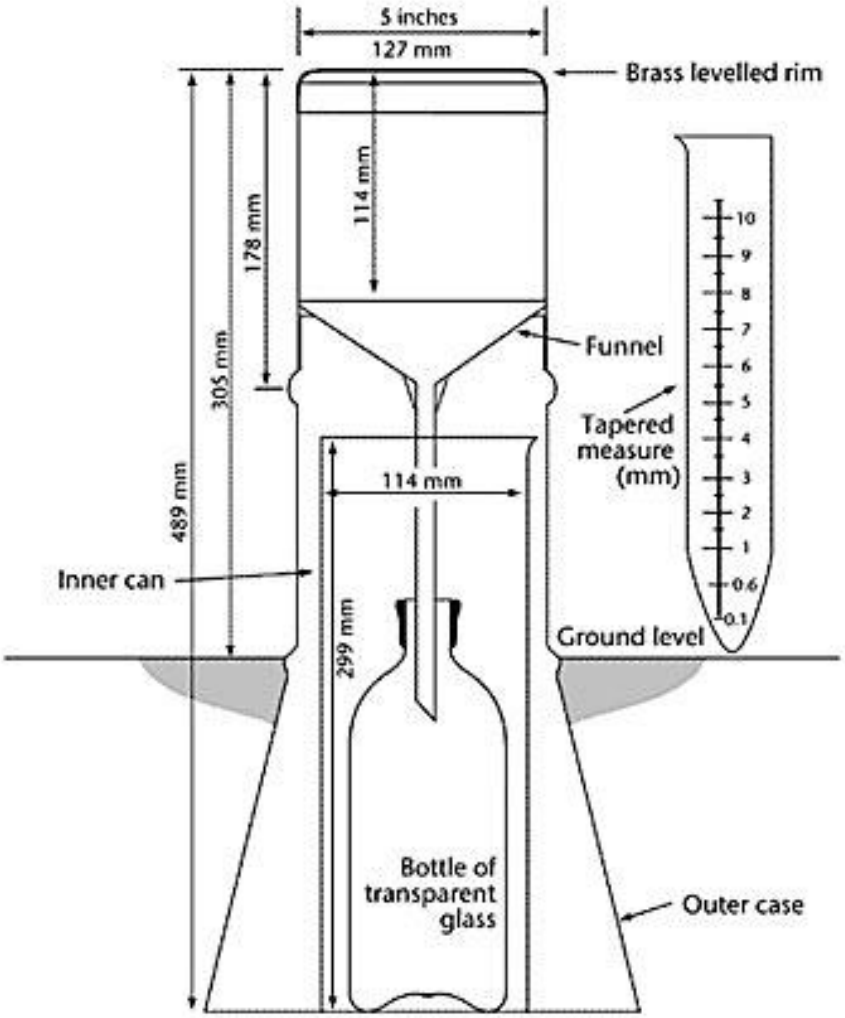
- Total rainfall for a particular period could be obtained
- Observations are taken at the end of 24 hours period or lesser intervals during heavy rain
- The Symons rain gauge - most common type with following specification
  - Cylindrical vessel of 12.7 cm in diameter.
  - Funnel of 12.7 cm in internal diameter.
  - Receiving bottle capable of collecting 10 cm of rainfall

Demerits

- Intensity and duration of rainfall not recorded
- No indication on start and end of rainfalll
- Not very accurate

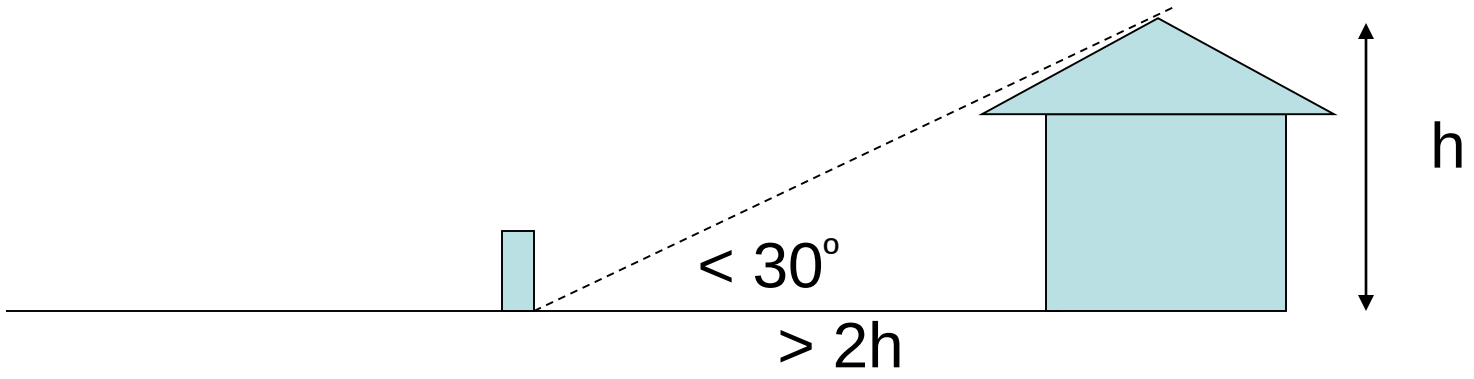
- Use non-recording rain gauge to measure a rainfall in class

Non-recording rain gauge



Location of Rain gauges

- at least 75 cm above the ground level.
- should be located in an open space free form obstructions.
- distance of this rain gauges should be at least twice of the height of the obstruction.
- uneven topography should be avoided



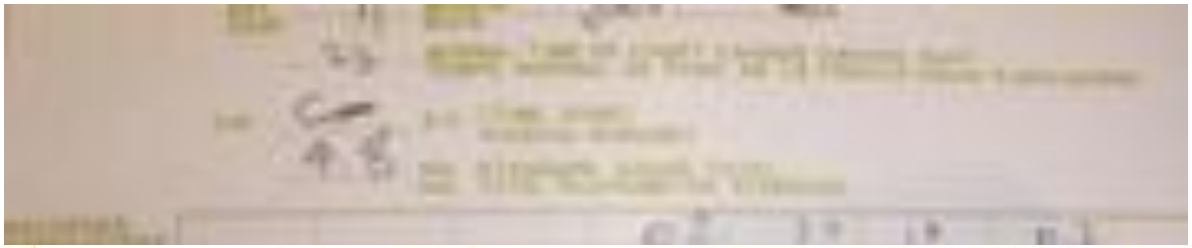
Mean Annual Rainfall

- Simple average of annual rainfall of several consecutive years

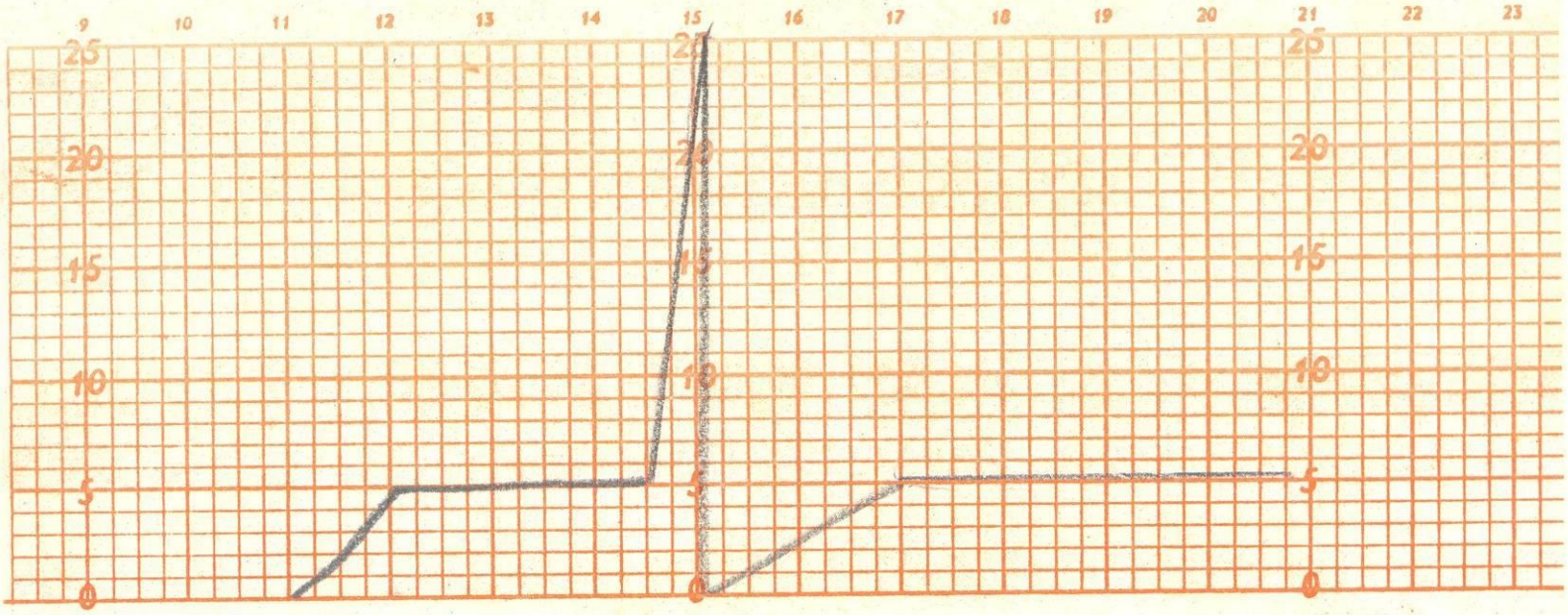
Rainfall Intensity

- rate at which rainfall occurs is known as the intensity
- expressed as cm/h or mm/h
- using automatic rain gauge charts

- Show a recorded chart



Gauge No. Year Month Time on d hrs.



Scale, 25 mm = 60 mm on chart

Station

To

Exercise 1

- Given recording rain gauge chart shows an actual rainfall event over a small tank catchment in Sri Lanka.
  - Find the total amount of rainfall
  - Find the maximum rainfall intensity, time at which it occurred and its duration.
  - The tank has a water surface area of 20 ha, a catchment area of (excluding water surface area) 5 km^2. If the water level was raised by 0.45 meters due to this rainfall event, calculate the fraction of rainfall that contributed to the runoff (neglect increase in water surface area with increasing volume for the reservation and other losses)
  - As a student of hydrology, what does this fraction signify in terms of simple rainfall runoff relations.

Average depth of rainfall over an area

- For any storm, the rainfall over a large area will not be the same
- If sufficient number of rain gauges are located spread over the entire area, each rain gauges will record certain depth of rainfall
- To calculate average rainfall for the entire area, three method are available.
  - Arithmetic Mean method.
  - Thiessen method.
  - Isohyetal method.

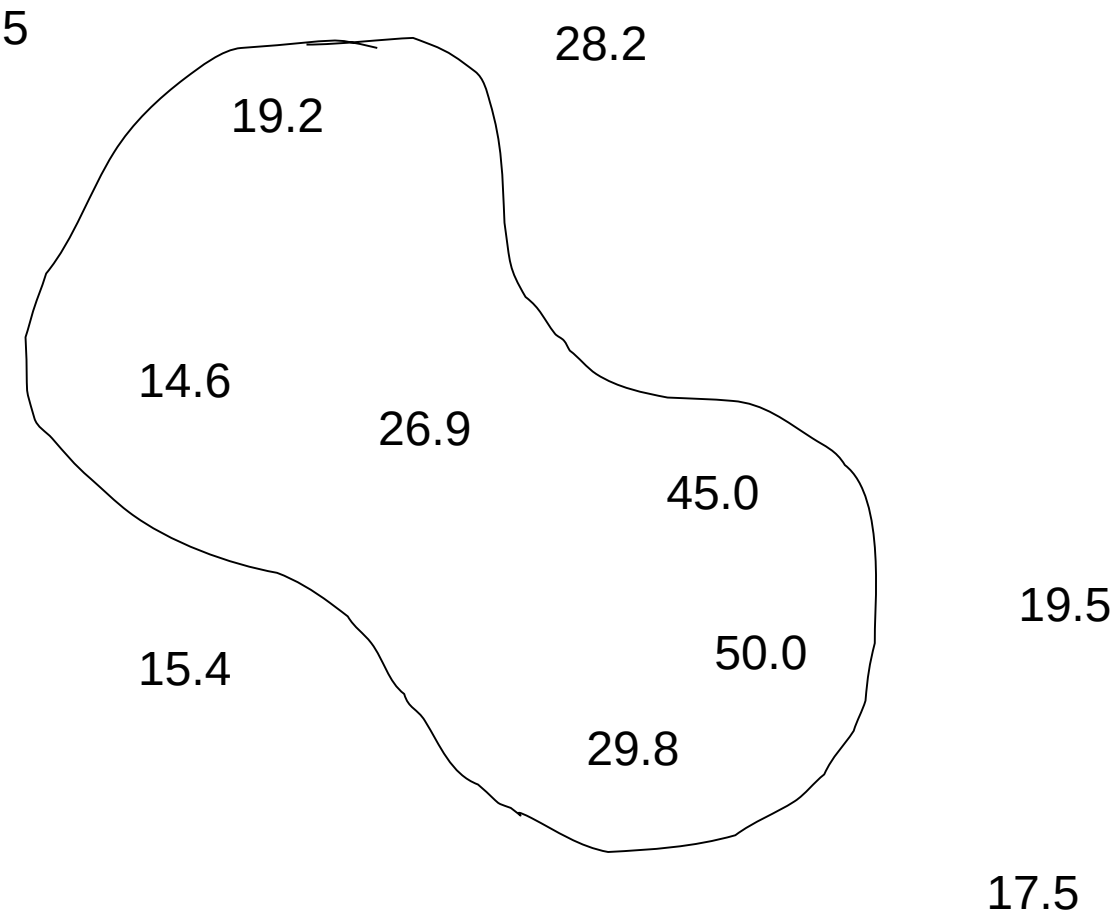
Arithmetic Mean method

- average rainfall is obtained by dividing the sum of depths recorded at all station in the area by the number of stations
- gives reasonably accurate results if
  - gauges are distributed all over the area
  - rainfall varies in a regular manner

$$Arithmetic\ mean = \frac{\sum_{i=1}^{i=n} RF_i}{n}$$

Exercise 2

- Calculation the equivalent depth of rainfall for the basin for a storm whose recorded depths are shown in Figure by all three methods.


6.5
28.2
19.2
14.6
26.9
45.0
19.5
50.0
15.4
29.8
17.5

Thiessen method

- Location of rain gauges are plotted on a map of the area and the station are connected by means of straight lines.
- Perpendicular bisectors are constructed on each of the lines in such a way each rain gauge is enclosed in a certain area.

$$Average\ Rainf\ all = \frac{RF_1 * A_1 + RF_2 * A_2 + RF_3 * A_3 + ...}{A_1 + A_2 + A_3 + ...}$$

Isohyetal method

- isohytals (lines of equal rainfall) are drawn by interpolation
- area between successive isohyets determined

Estimating Missing Precipitation Data

1. Normal Ratio Method

$$P_x = \frac{1}{3}\left(\frac{N_x}{N_a} P_a + \frac{N_x}{N_b} P_b + \frac{N_x}{N_c} P_c \right)$$

where,

P = Precipitation in question

N = Normal annual precipitation

2. Graphical Method

Missing rainfall based on 2 adjacent stations

Plotting of mass curve and rainfall

Intensity Curve